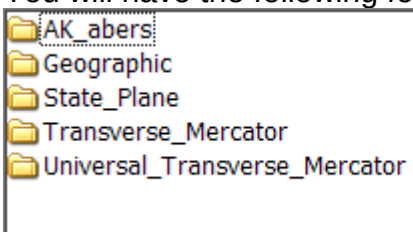
Lab#3: GIS Projections and Coordinate Systems

In this lab, you will

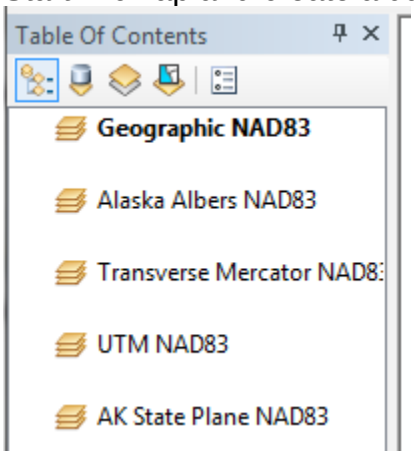
1) Define the geographic coordinate system of two GIS themes.
2) Determine the geographic coordinates for some locations in Alaska
3) Change your projection from geographic to the Alaska Albers coordinate system
4) Create a new projected coordinate system in the Transvers Mercator Projection
5) Project from geographic to the UTM coordinate system, determine maximum scale error within a UTM zone
6) Project from geographic to the Alaska State Plane coordinate system, determine maximum scale error within a State Plane zone

Download and unzip the file ***lab3.zip*** from the following website:
http://dverbyla.net/nrm338/data/

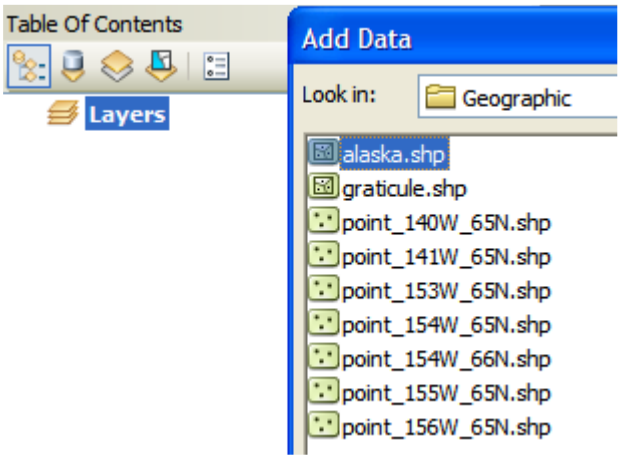
Unzip the file to your own folder in C:\nrm338\
You will have the following folders in your lab3 folder:

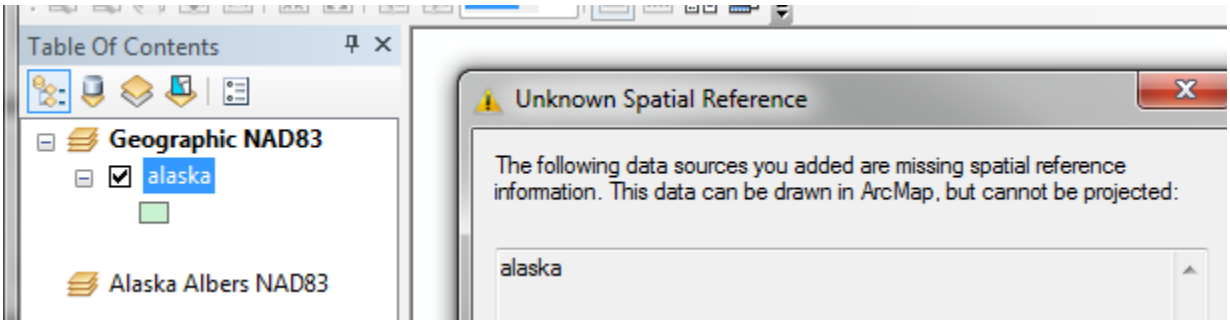


Start Arcmap and create a data frame for each of the above coordinate systems.



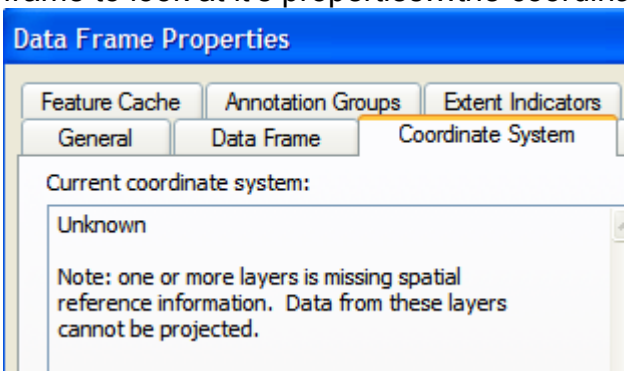
Add the polygon theme called ***alaska.shp*** from your Geographic folder to your arcmap data frame



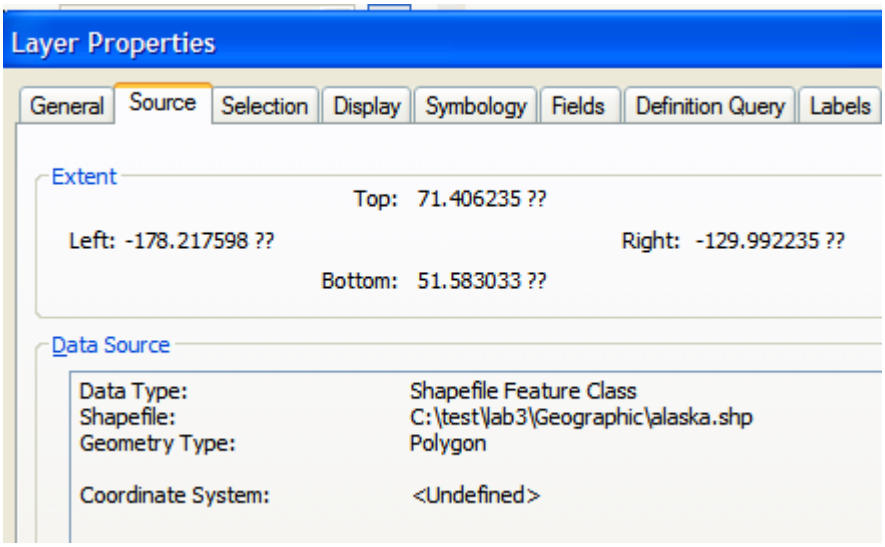


The warning message is that the alaska layer X,Y coordinates have not been defined and are unknown.

Your data frame will be set to the same coordinate system as the first theme that you add to that frame. What was the data frame coordinate system set to? Right mouse click on your data frame to look at it's properties…the coordinate system is unknown…

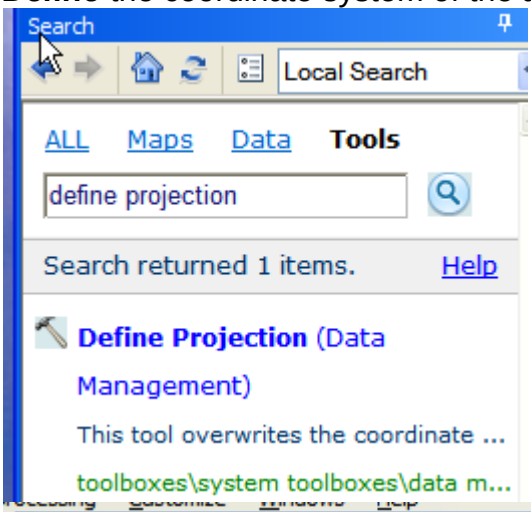


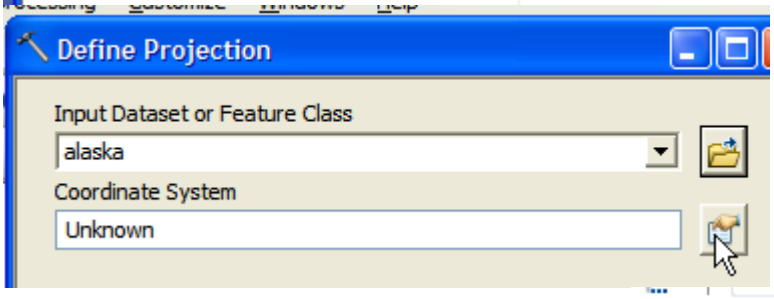
The first layer added to your data frame had X,Y coordinates, but Arcmap does not know what the coordinates system is…you must specify the correct coordinate system!

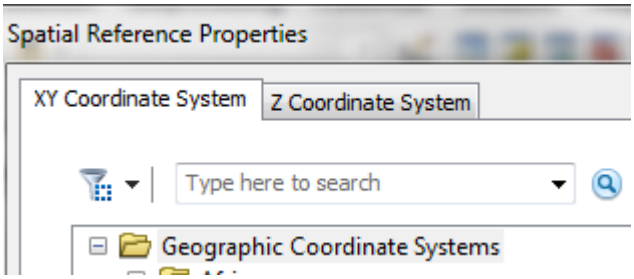


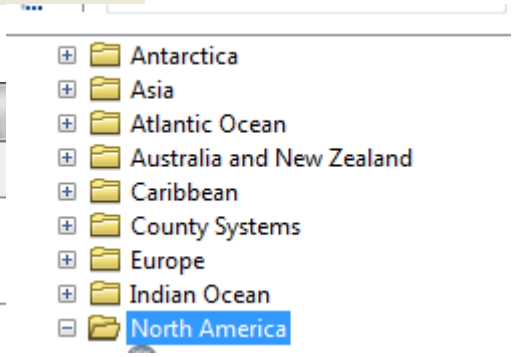
You will define the coordinate system by using the Define Projection geoprocessing tool.

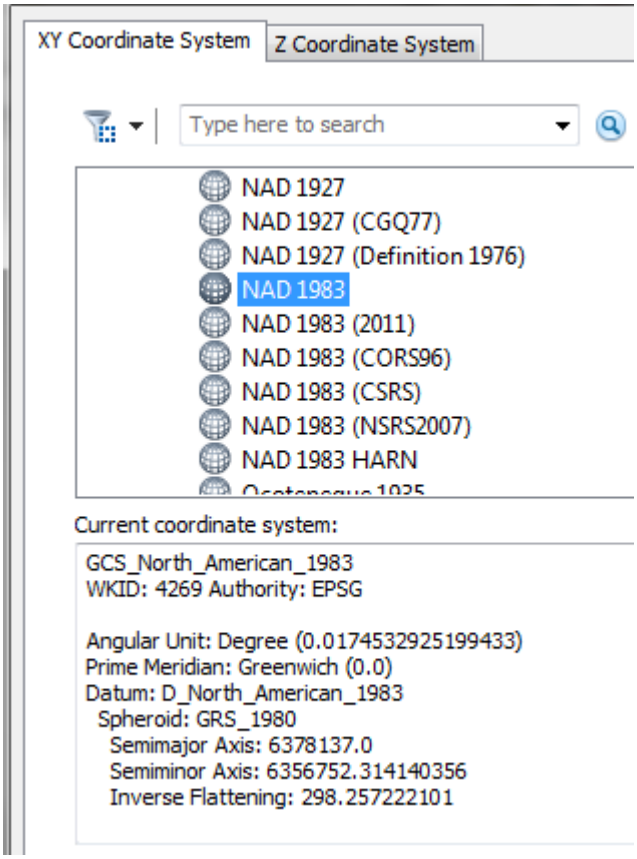
Define the coordinate system of the ***alaska*** layer as geographic, NAD83











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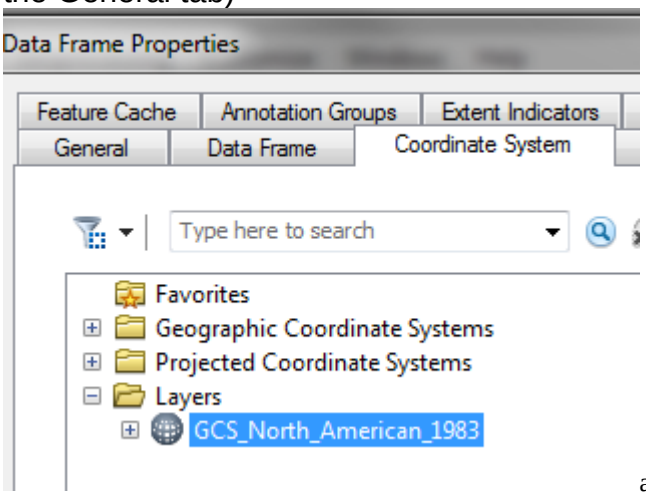
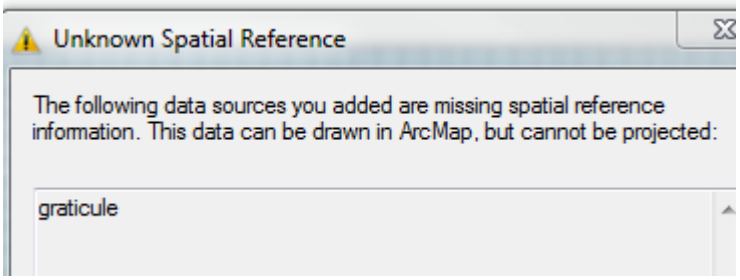
Set your data frame coordinate system to the NAD83 coordinate system so there is no conflict between your map frame and the map layer…and name your data frame ***GCS NAD83*** (use the General tab)



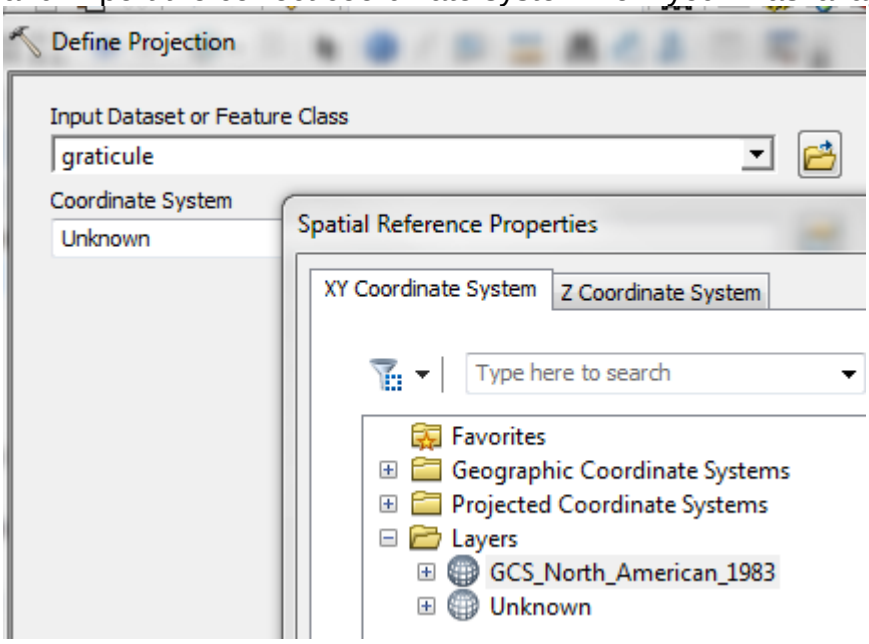
and press the OK button to assign this as your data frame coordinate system

Now add the ***graticule.shp*** from your Geographic folder to your map…

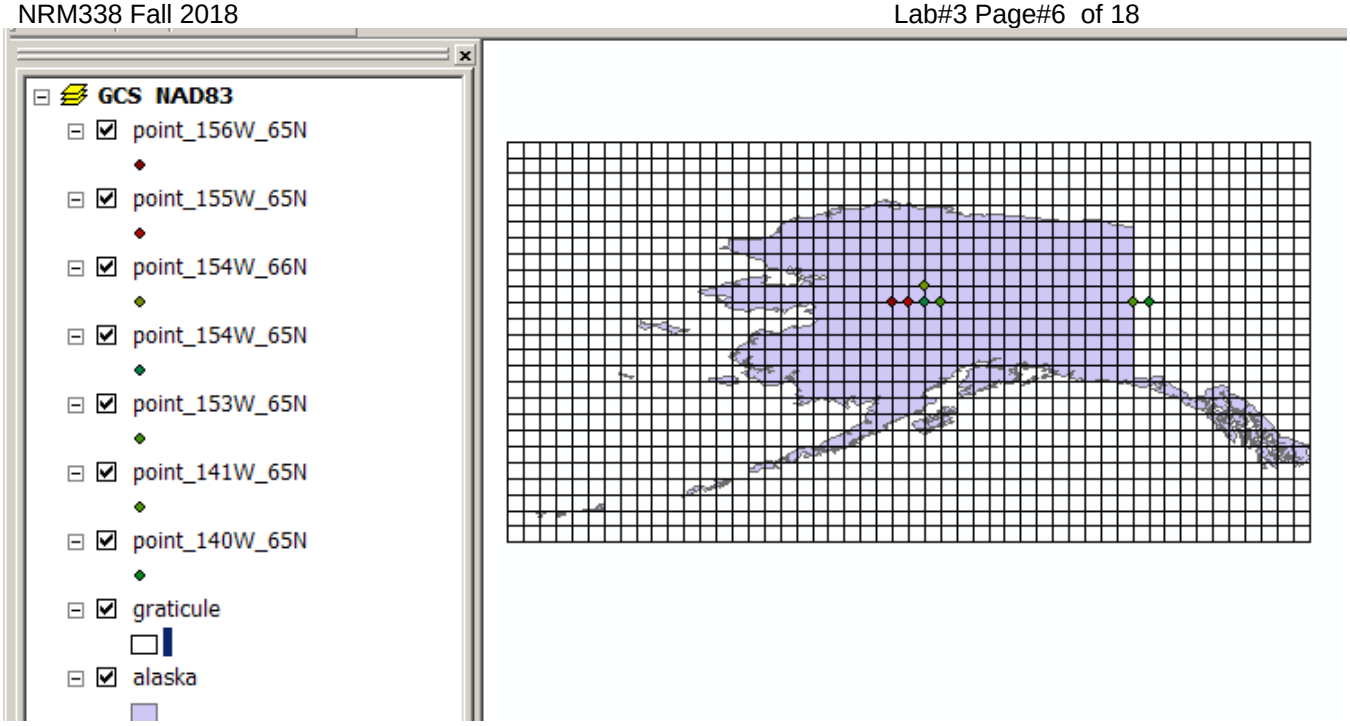


Next define your projection using the ***Define Projection tool*** for the graticule layer….only this time, import the information from your defined layer…

and import the correct coordinate system from your Alaska layer.



We defined the coordinate system of the point themes in your geographic folder for you as geographic NAD83. Add these seven point themes to your map.

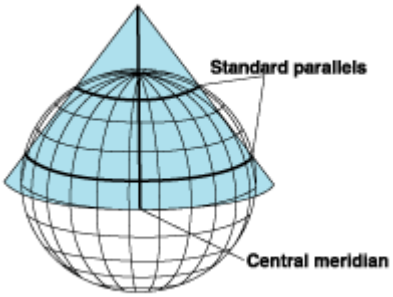


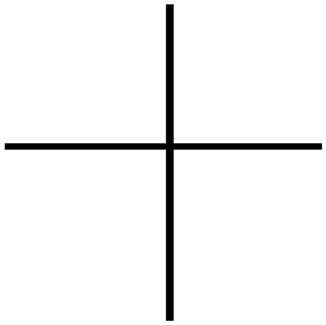
Zoom to the full extent of all themes…
The Alaska theme is not all of Alaska…some of the Aleutians are further east and south.

Use your pointer tool to determine the longitude and latitude of the following :
longitude of Alaska/Canada border north of the Wrangell Mountains: ***-141 degrees***
latitude of northernmost arctic coast of Alaska: ***>71 degrees***
longitude of Alaska/Canana border at southern tip of southeast Alaska*:* ***-130 degrees***

Alaska Albers Statewide Projection

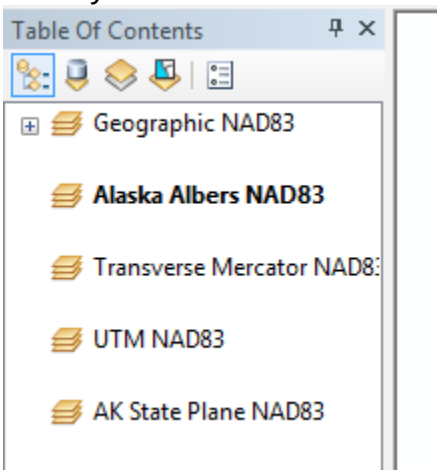
The Alaska Albers projection is a conic projection with the cone touching the globe at standard parallels of 55 and 65 degrees. The central meridian is the X-axis origin at 154 degrees west. The Y-axis origin is at 50 degrees north.



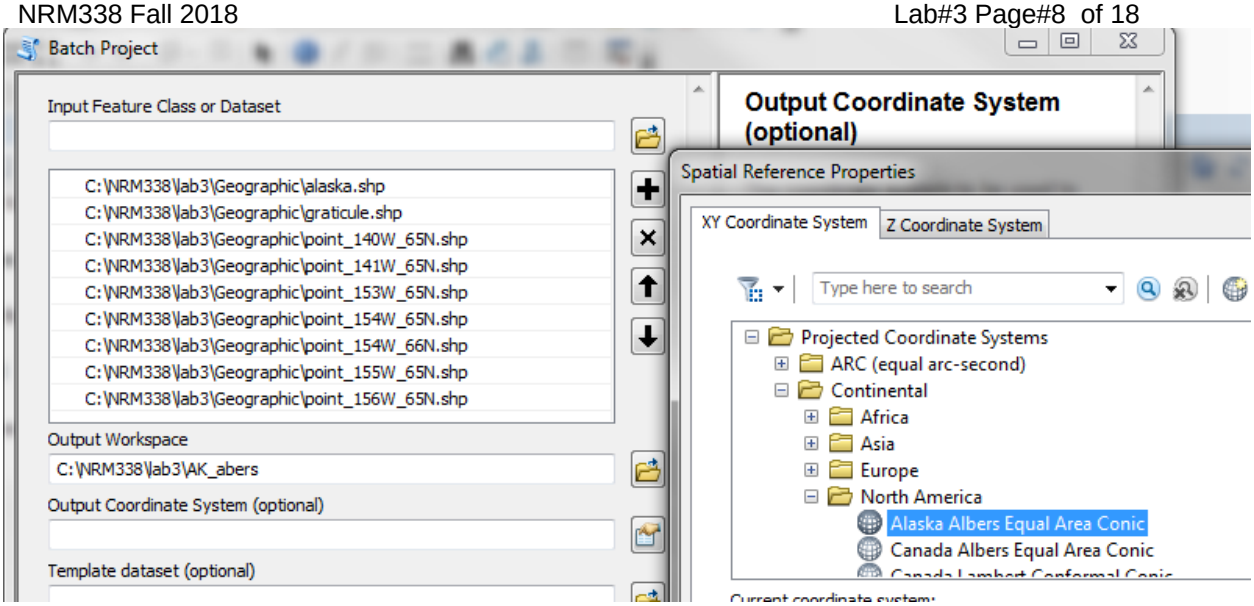


It is used by natural resource management agencies like the National Park Service, U. S. Fish and Wildlife Service, etc. that manage lands statewide.

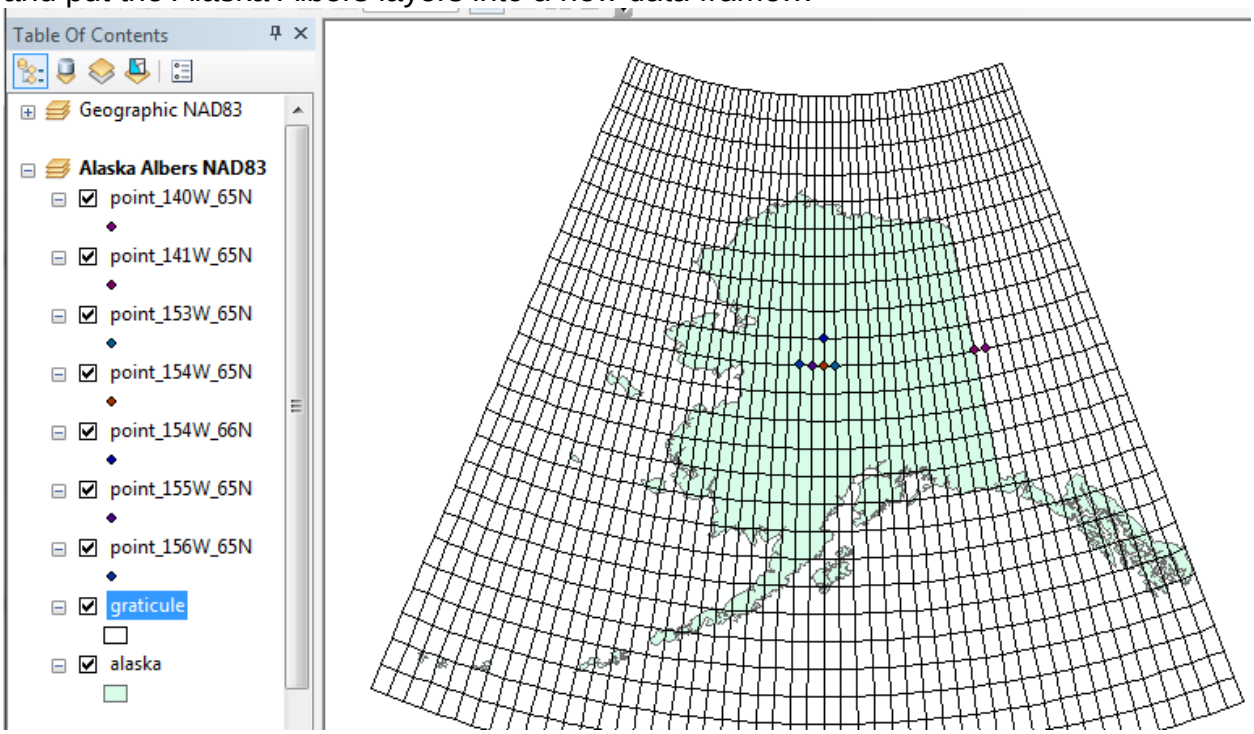
Make your **Alaska Albers Frame** *the active frame.*



Use the batch project tool to create output themes in the Alaska Albers projection…

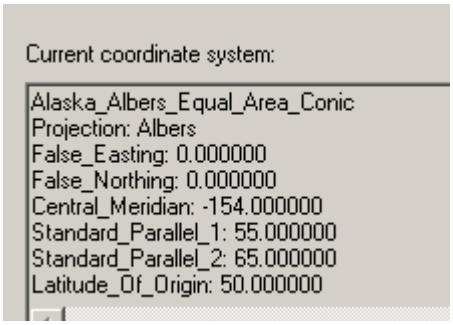


and put the Alaska Albers layers into a new data frame…

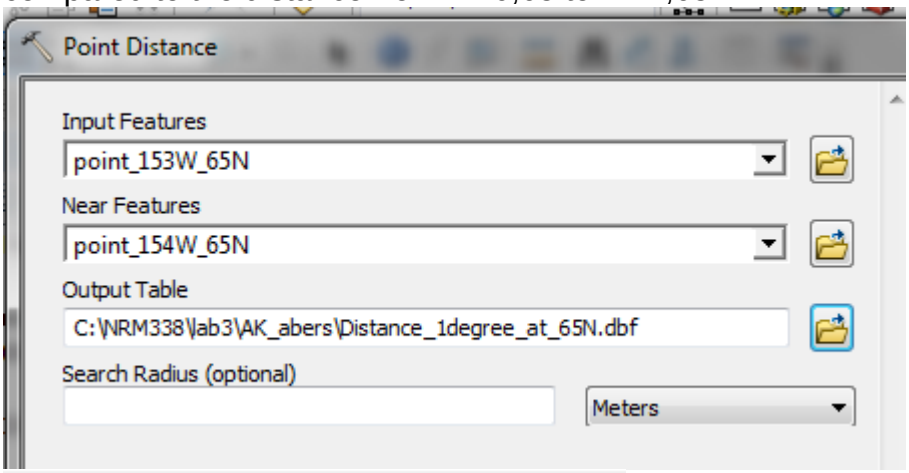


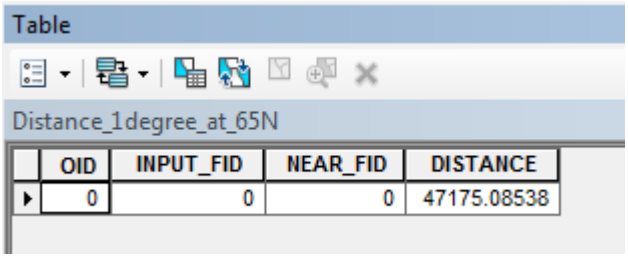
Notice that the north-south meridian that is straight up and down occurs at -154 degrees.

Use your pointer tool to determine the locations of the following:
In the Alaska Albers Coordinate System, Y value of 0 meters, what is the latitude? ***50º***
In the Alaska Albers Coordinate System, X value of 0 meters, what is the longitude? ***-154º***



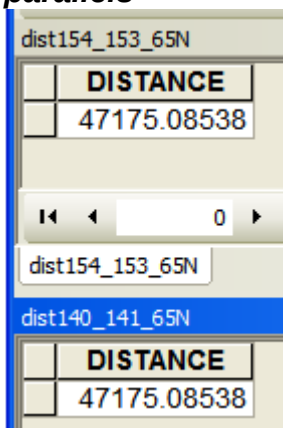
There should be no scale distortion east-west at the standard parallels of 55 and 65 N, since this is where the projection touches the globe.
Use your **Point Distance tool** to determine the distance from from -154,65 to -153,65 compared to the distance from -140,65 to -141,65.



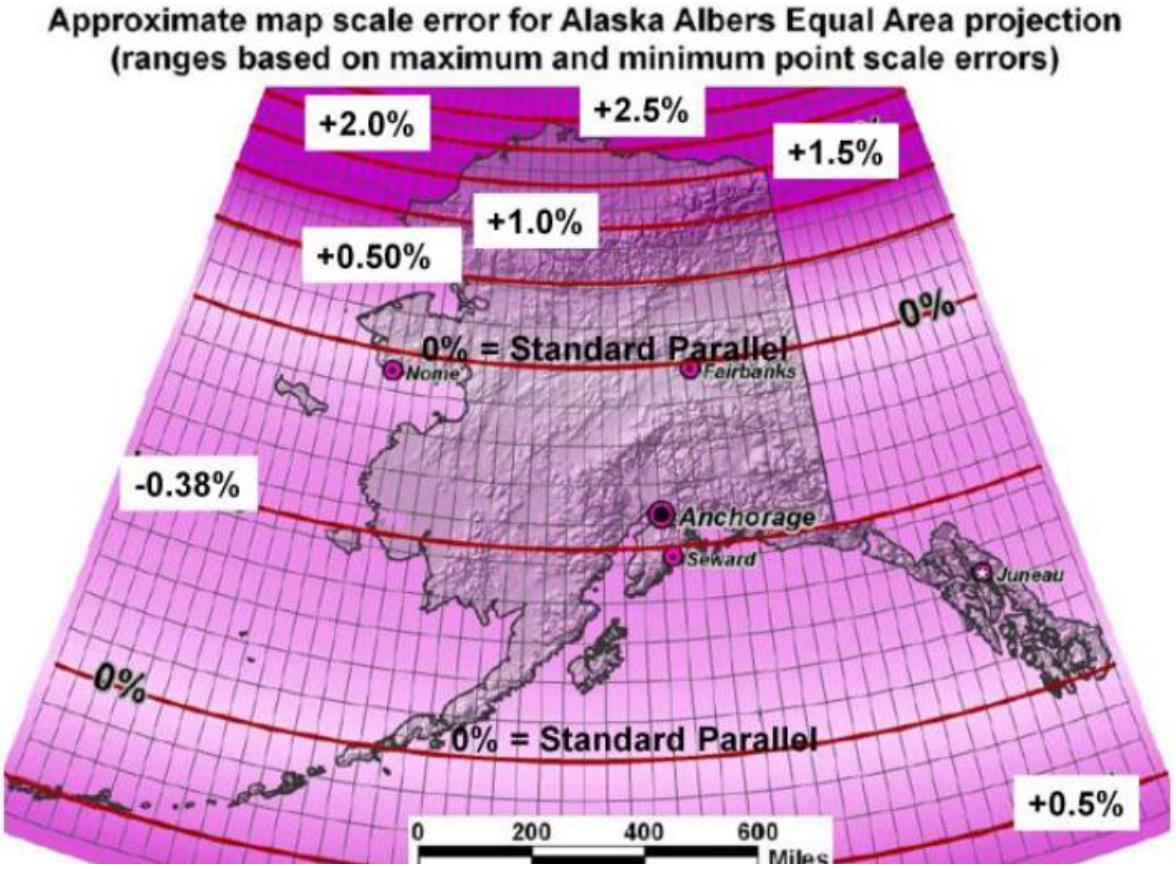


What is the distance from -154,65 to -153,65 compared to the distance from -140,65 to -141,65

Exactly the same---47,175.085 meters…there is no scale distortion along the standard parallels

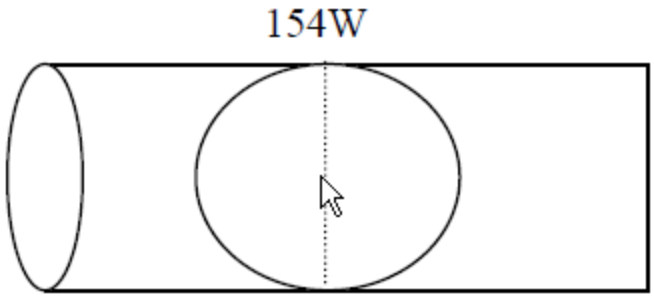


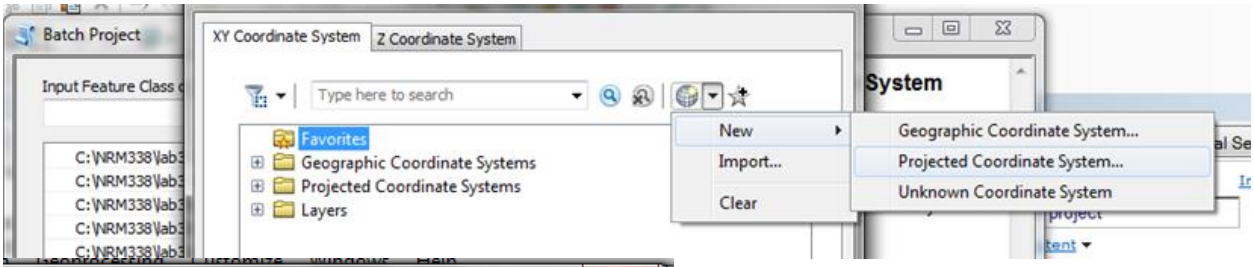
So the bottom line is that the Alaska Albers projection is excellent for mapping east-west near 55 or 65 degrees of latitude. Scale distortion increases as your north or south from the standard parallels.

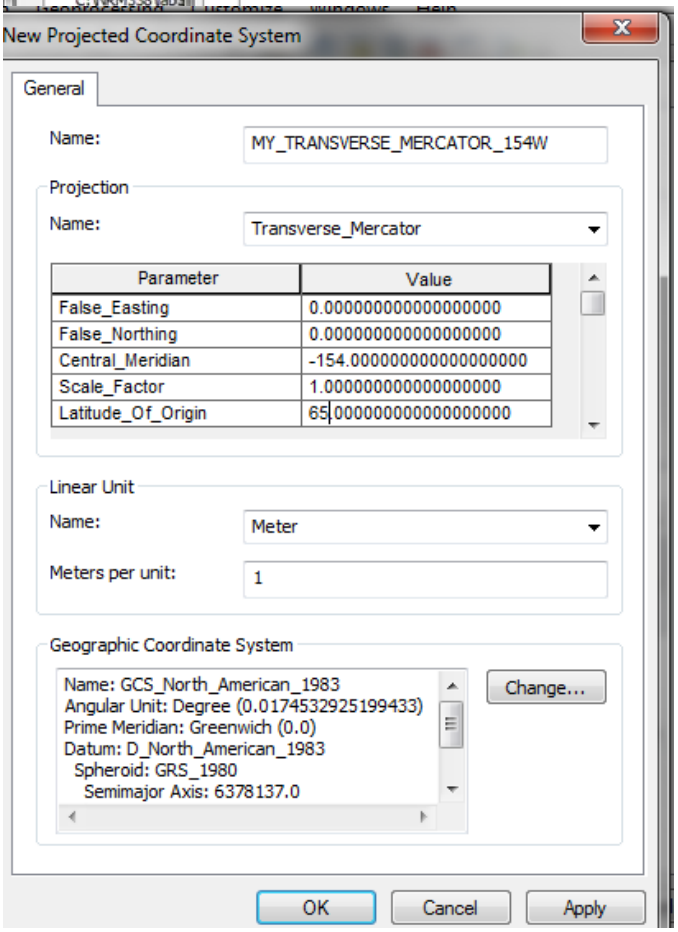


Transverse Mercator Projection

Next batch project your to layers from your geographic folder to a ***new*** projected coordinate system defined as cylindrical projection touching the globe at -154 degrees west

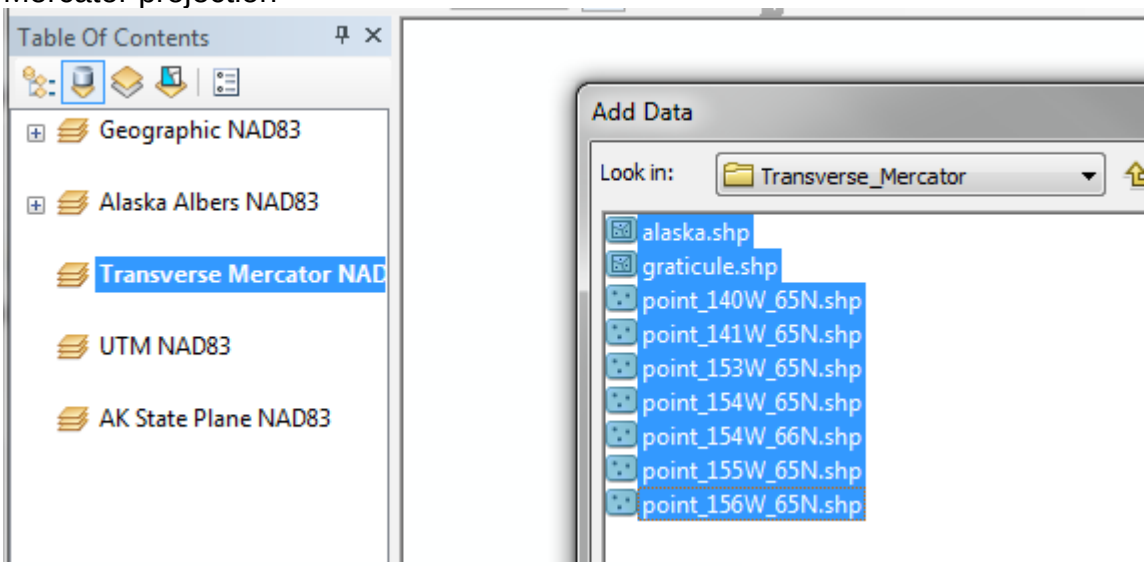


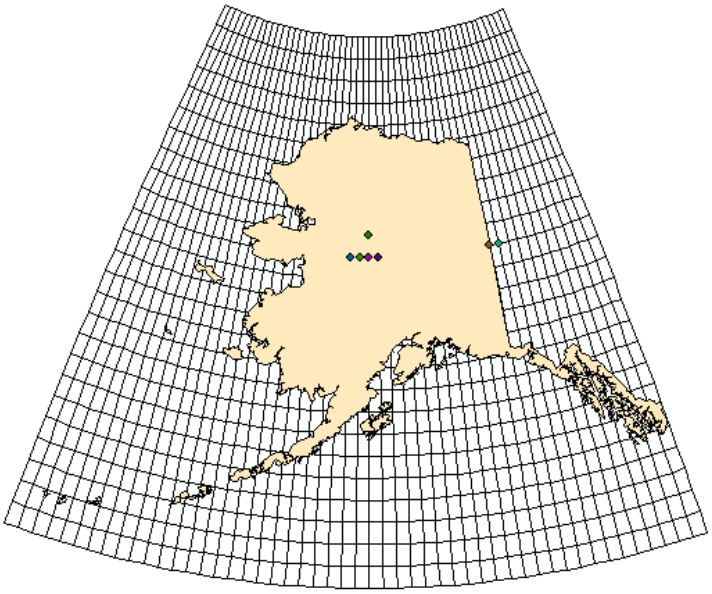




Note that the geographic coordinate system is NAD83, the Transverse Mercator Cylinder touches the globe perfectly at 154 degrees west, and the y origin is specified as 65 degrees north.

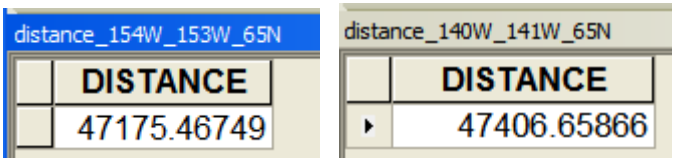
Activate your Transverse Mercator data frame and add your themes that are in the Transverse Mercator projection





What is the longitude where X is zero in this coordinate system? ***-154 degrees***
What is the latitude where Y is zero in this coordinate system? ***65 degrees***

Use your **Point Distance Tool** to determine the distance from -154,65 to -153,65 compared to the distance from -140,65 to -141,65



Notice that the scale distortion increases east and west of the central meridian of 154W. From earlier in the lab, we found that 1 degree of longitude at 65 degrees north is a distance of ***46175 meters. Notice nearer the Central Meridian of -154, there is less scale distortion.***

```
Projection: Transverse_Mercator
False_Easting: 0.0
False_Northing: 0.0
Central_Meridian: -154.0
Scale_Factor: 1.0
Latitude_Of_Origin: 65.0
Linear Unit: Meter (1.0)
```

The scale factor is 1.0 at 154 degrees west, and increases east or west of this longitude.

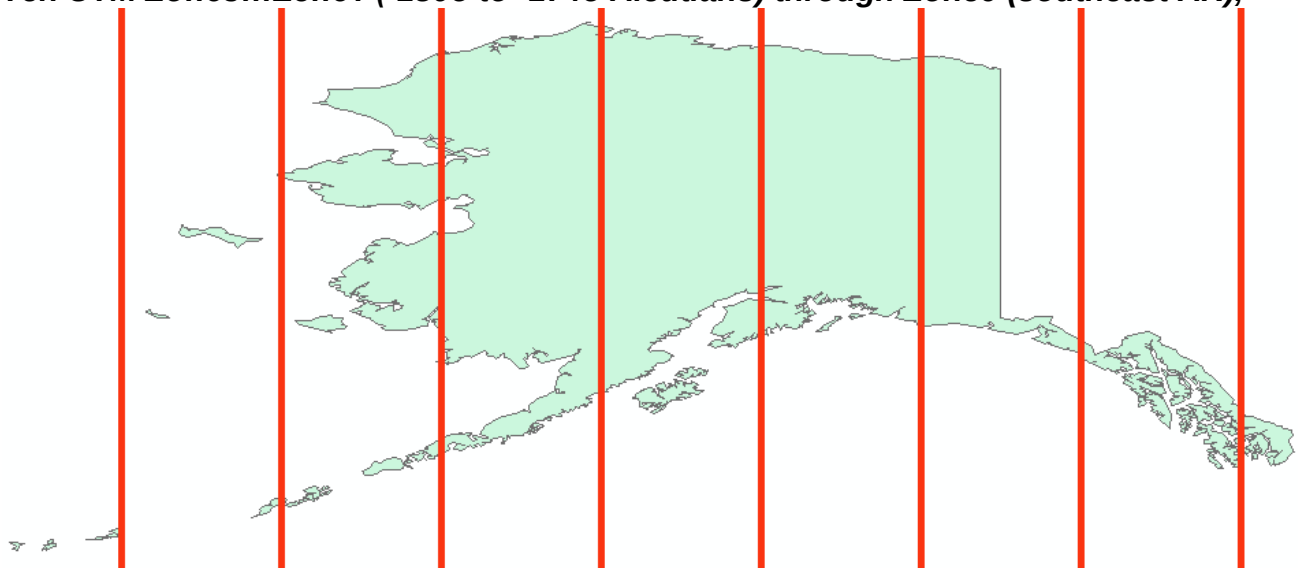
How bad is the scale distortion between 140-141W? ***47406 - 47175 = 231 meters too large***

UTM Coordinate System

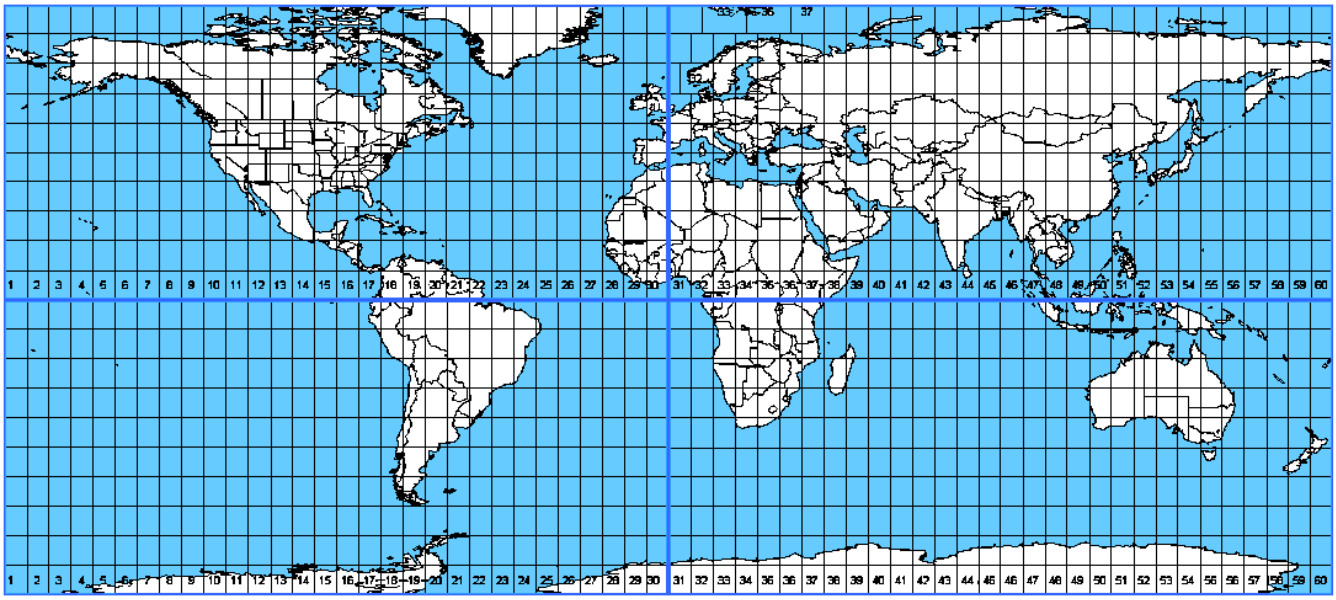
The UTM coordinate system are metric X,Y coordinates in the Transverse Mercator projection. To minimize scale distortion, the system uses 6 degree wide zones starting at zone 1 from -180 to -174 longitude, zone 2 from -174 to -168, zone 3 from -168 to -162, etc.

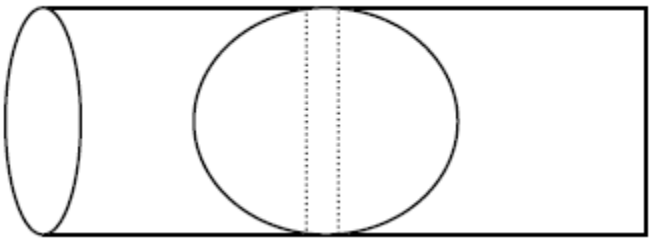
How many UTM zones are there in Alaska?

Ten UTM Zones…Zone1 (-180o to -174o Aleutians) through Zone9 (southeast AK),



PLUS UTM Zone 60 in the eastern Aleutians



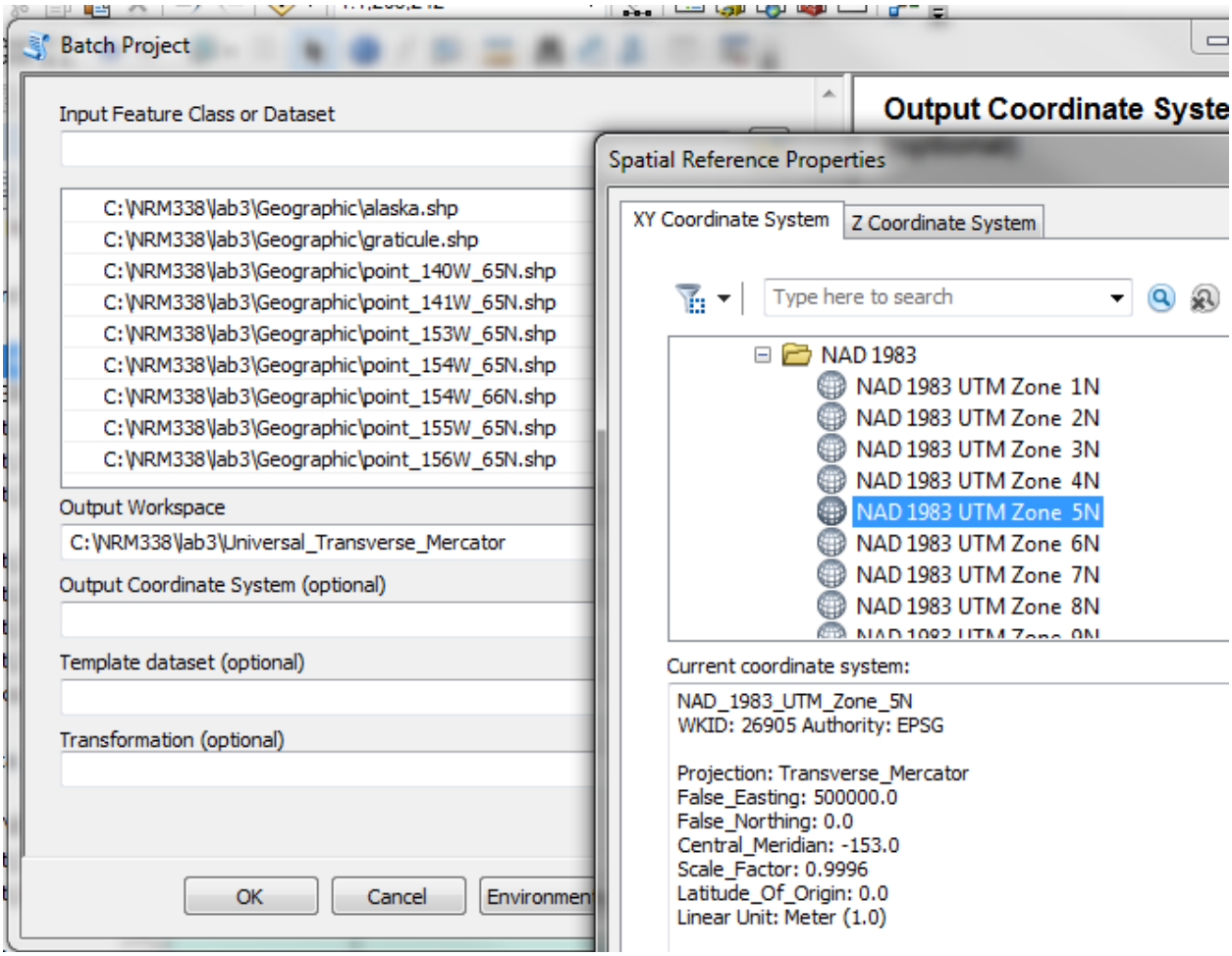


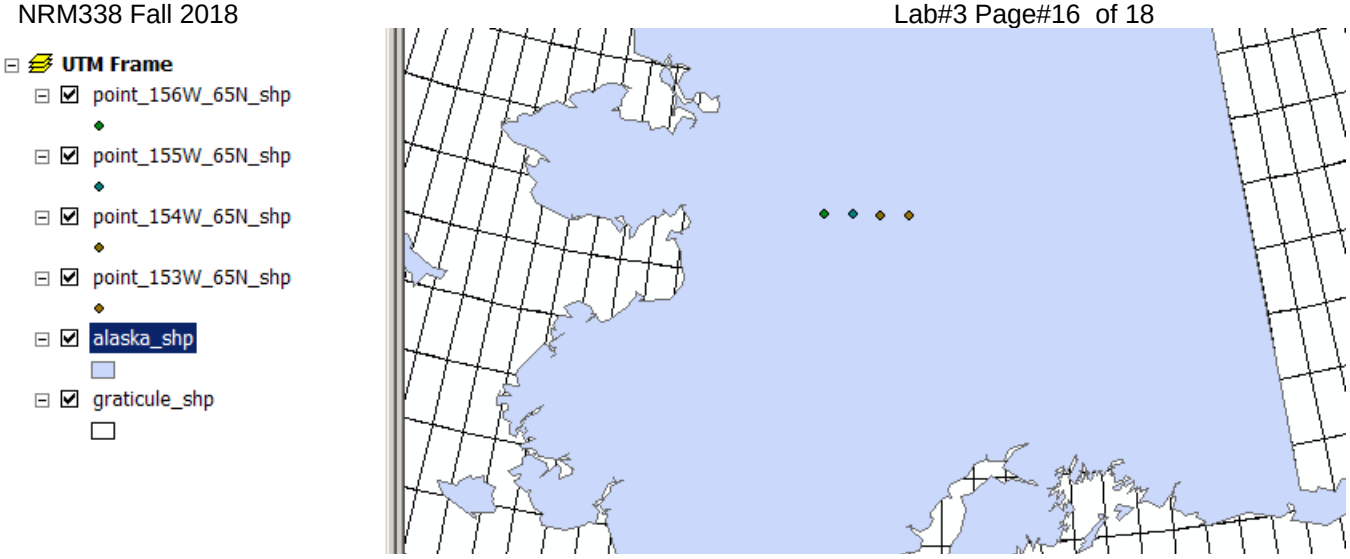
Each UTM Zone is 6 degrees wide, for example zone 6 is from -144 to -150 longitude.

The UTM projection touches the globe 180 km east and west of the center of the zone. That is where the scale distortion is zero. The scale is greater than one east and west of these meridians. The ***scale factor at the center of the zone is 0.9996***. Metric Y values are assigned as northings: distance north of the equator. Metric X values are arbitrarily assigned as ***false eastings of 500,000 m at the center of each zone***.

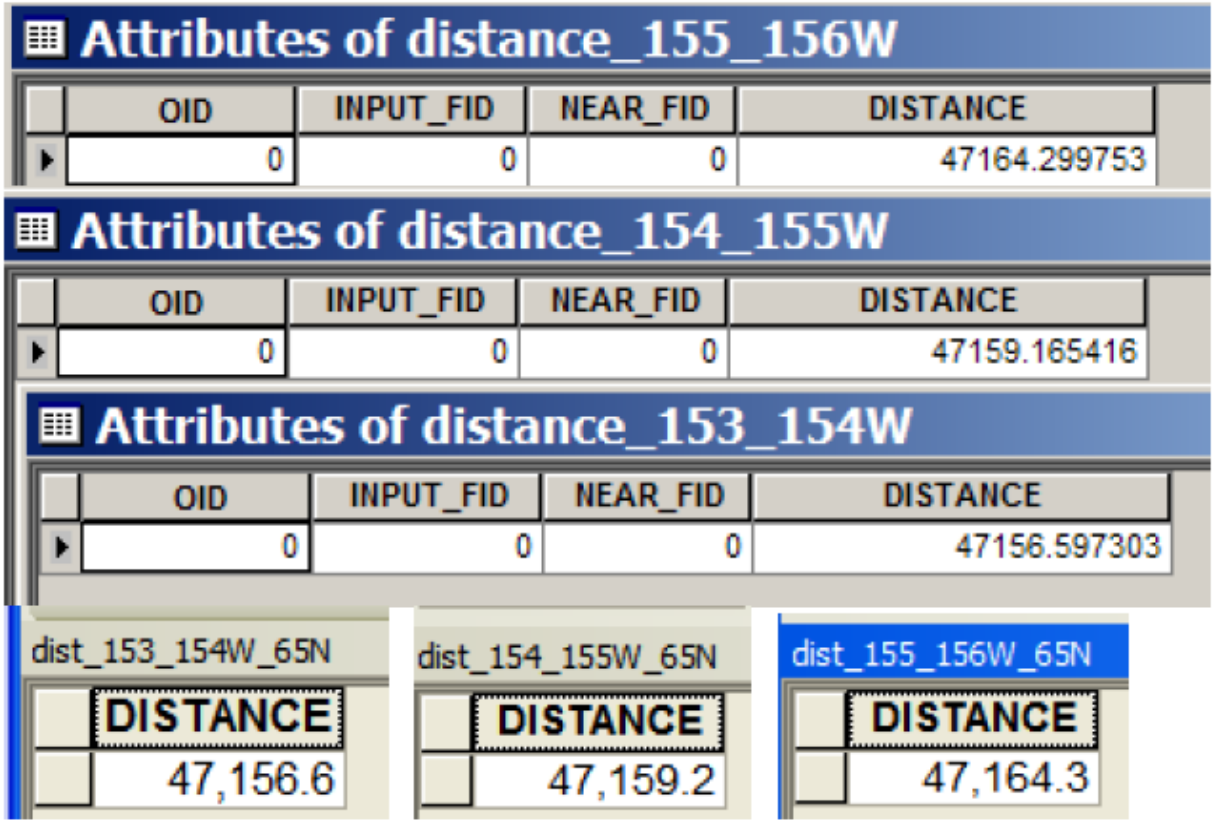
Batch Project your layers from your Geographic folder into the UTM NAD83 coordinate system.

What zone should you project to? Since the longitudes range from -153 to -156, they are within UTM zone 5 (-150 to -156 degrees)





Use your **Point Distance** tool to determine the distance between your four points within the UTM zone.



How bad is the scale distortion? Remember the distance was 47175 with no scale distortion when you measured along the standard parallel in the Alaska Albers projection.

47164 - 47175 = -11 meters
47159 – 47175 = -16 meters
47157 – 47175 = -18 meters
The worst scale distortion is at a scale factor of 0.9996
= 0.0004 * 47175 = 18.87 meters

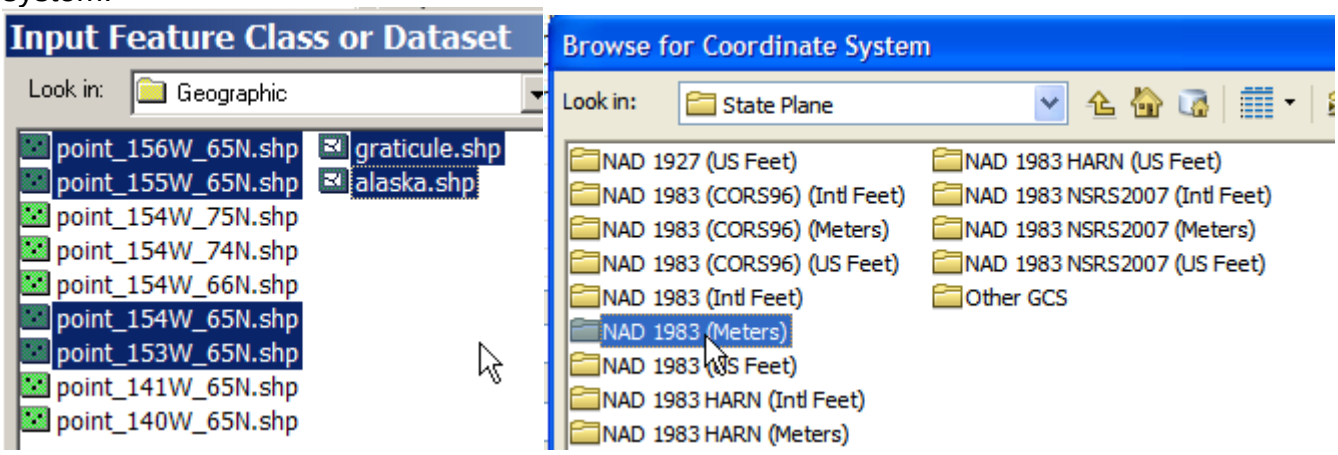
State Plane Coordinate System

Some applications such as city and burough GIS parcels, transportion analysis, etc. require a projection with maximum scale distortion less than 18 meters. This can be achieved by making the zones 4 degrees wide instead of 6 degrees wide. For Alaska, there are 8 zones in the Alaska State Plane coordinate system that use the Transverse Mercator Projection. (Zone 1 is in the Aleutians and uses a conic projection, while Zone 10 is in southeast Alaska and uses a rotated mercator projection)

Zone	Central Meridian	Scale Factor
2	142W	0.9999
3	146W	0.9999
4	150W	0.9999
5	154W	0.9999
6	158W	0.9999
7	162W	0.9999
8	166W	0.9999
9	170W	0.9999

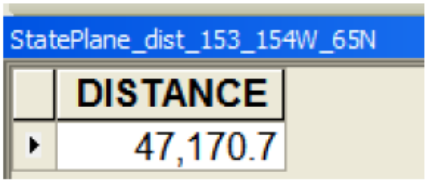
The Y value in this coordinate system represents the distance north 54 degrees. The X value is a false easting with the center of each zone assigned a value of 500,000 m.

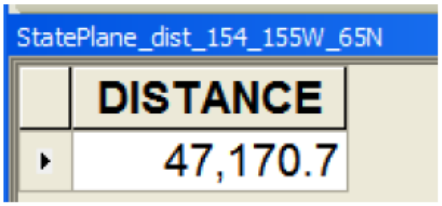
Batch Project your layers from your Geographic folder into the State Plane NAD83 coordinate system.

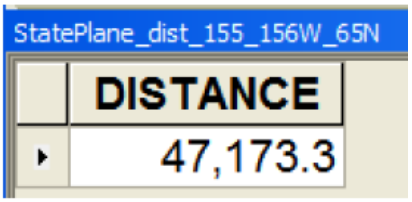


What zone should you project to?

Use your **Point Distance** tool to determine the distance between your four points within the State Plane zone.







How bad is the scale distortion?
47173 - 47175 = - 2 meters
47171 – 47175 = - 4 meters
47171 – 47175 = - 4 meters

The worst scale distortion is at a scale factor of 0.9999
= 0.0001 * 47175 = -4.7 meters
So the State Plane Coordinate System has less scale distortion, but it is restricted to zones that are 4 degrees wide.